Retake exam

Thermal Energy Conversion (SEE020)

2023-08-22, 08:30 - 12:30

Examiner	David Pallarès (tel.nr. 031 772 1435)
Allowed resources:	calculator, course book, formula sheet
Mark scale	Mark 5: at least 24 p Mark 4: at least 18 p Mark 3: at least 12 p Not passed: less than 12p
Exam review	week 35 (after agreement via e-mail: david.pallares@chalmers.se)

1. Describe the concept of negative CO_2 emissions, and explain a process through which they can be attained. **(2p)**

2. Liquid/liquid heat exchangers base their performance on convective heat transfer. Explain:

a) what is the so-called no-slip condition, and why is it important in the study of convective heat transfer **(2p)**

b) why, within the same flow regime region, the convective heat transfer coefficient decreases along the tubes as the flow develops **(2p)**

3. A stream of hot (50^{o}C) water flowing inside a channel is to be refrigerated by surrounding cold air (10^{o}C). You are given some possibilities regarding the material and thickness for the channel:

	Thermal conductivity [W/m·K]	Thickness [mm]
Steel	13.4	4
Iron	42.3	3
Wood	0.113	11
Plastic	0.33	15

You are also given the possibility to add flanges, both regarding the location (on the water side, or the air side of the channel, or none), and the size of the flanges (small, medium or large).

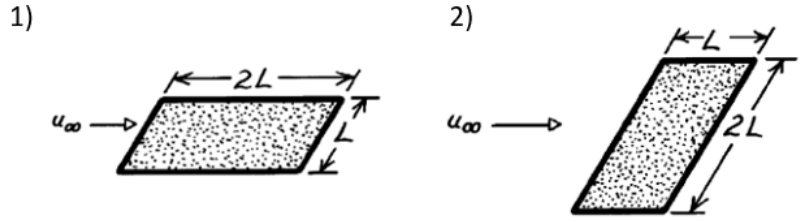
a) What would be your choice of material and flange location and size? **(3p)**

b) Regarding radiation: would you consider taking any measures to increase the radiative heat exchange between the channel and its surrounding? And any measures to avoid solar irradiation? Explain your answer. **(2p)**

4. A plate surface with dimensions 6m*3m is cooled by means of a forced external gas flow, yielding a heat removal rate of 53 kW. The plate is oriented so that the gas flow along the long side and across the short side (see left drawing below). You are requested to calculate whether a change in the orientation of the plate (as skissed in the right drawing) would yield a higher heat removal than the original (left drawing) one. Assume that laminar conditions are kept all over the plate for both orientations.

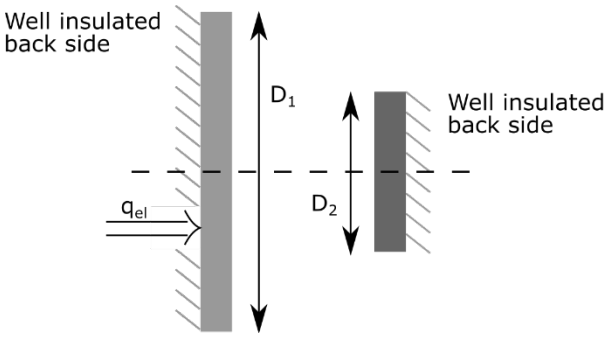
a) based exclusively on theory (thus without doing any calculation), what would be your answer: will the alternative orientation provide a higher heat removal rate? **(1p)**

b) how much will be the heat removal with the alternative orientation proposed? **(3p)**



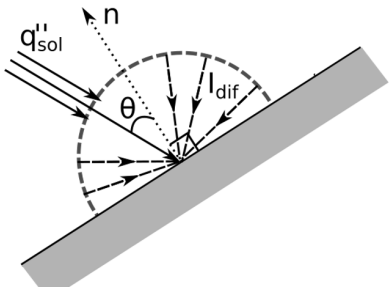
5. Two discs are placed so that they are parallell and coaxial (have the same axis), according to the figure below. The larger disc (1), with a diameter of 0.25 m, is electrically heated so that it reaches a temperature of 150°C. Heat is transferred due to radiation from the larger disc to the opposite, smaller disc (2), which has a diameter of 0,10 m. The back side of both discs are well insulated and the large surrounding surfaces and air holds a temperature of 27°C. The view factor F_{12} is determined as 0.09 and disc 1 can be considered as a blackbody.

a) What will be the temperature of the smaller disc at steady state conditions if all heat transfer can be considered to be due to radiation? State the assumptions that you make. (**4p**)
b) In an attempt to determine the emissivity of the smaller disc you force air over the surface of the smaller disc, receiving a convective heat transfer coefficient of 25 W/m^{2}K. In your experiment you measure the temperature of the smaller disc as 70°C, while the temperature of the larger disc is not affected. Determine the emissivity of the smaller disc. (**2p**)



6. Consider the following conditions at a mirror in CSP park. The sky is clear and the direct irradiation from the sun to the mirror is $q''_{sol} = 1100\ W/m^2$ and it is incident at $\theta = 25°$, according to the figure below. The diffuse intensity incident to the mirror, I_{dif}, is $75\ W/m^2 sr$.

a) Determine the total irradiation to the mirror. (**2p**)
b) Discuss the different contributions of direct and diffuse irradiation to a CSP plant and how these changes if a clear day becomes cloudy. (**1p**)



7. You are to design a heat exchanger for a currently build vessel (ship) cooling the refrigerant with the seawater. You have narrowed down the type of heat exchanger to wo types, a shell and tube and a plate heat exchanger.

Discuss the advantages and disadvantages for each option and go through all aspects relevant for the design. **(2p)**

8. The design for a boiler requires the calculation of the involved gas volumes to design the fan capacities. The fuel to be combusted is specified as below.

Calculate the air demand m3/kg_{fuel}l, the humid flue gas formed in m3/kg_{fuel} and the amount of water formed in kg water/kg_{fuel}. **(4p)**

Use the conditions of 25 °C and 10MPa for the calculations of the gas volumes and an air ratio of 1 (stoichiometric)

Fuel composition	kg_i/kg_{fuel}
C	0,857
H	0,143

Molar mass	kg_i/mol_i
C	0,012
H	0,001
CO2	0,044
H2O	0,018
O2	0,032
N2	0,028